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SLASH DISPOSAL IN WESTERN WHITE PINE FORESTS IN IDAHO

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If all sizes of material produced by a forest are salable, very little logging débris of slash remains to hinder the reproduction or to increase the fire hazard. In the white-pine type of northern Idaho, however, only the larger and most valuable forest products can at present be taken out at a profit. The virgin forests of this region yield from 15,000 to 40,000, and often 50,000, board feet per acre. They usually contain many fallen dead trees. Much material, in the form of branches, tops, and swamped undergrowth, is left after a logging operation. This débris may cover from 40 to 90 per cent of the forest floor and average from 1 to 3 feet deep. The uncut forest is shown in Figures 1 and 2 and logging waste in Figures 2 and 7.

Frequently, in addition to the débris, there is a dense understory of hemlock, white fir, and western red cedar, all of which becomes highly inflammable during the long, dry summer season, and especially so when the dry, hot winds blow from the desert region to the southwest.

With the increasing efficiency in fire protection, the suggestion has been advanced for this and other regions that the slash problem may possibly be solved by intensive protection after cutting without special provisions for the disposal of the slash. This suggestion may be practical in certain regions under local conditions and eventually, with close utilization of the forest, it may become the prevalent method of dealing with this problem. Where slash has been left in

the western white pine region there has never been protection intensive enough to prevent fire, so that data from actual tests are not available. With the large amount of slash resulting from logging, this plan can not be considered under present protection standards because of the practical certainty that some fires will start in dry seasons and of the extreme difficulty, approaching impossibility, of suppressing them at reasonable costs, particularly during periods of high winds. In the light of present experience, the logging waste or slash must, therefore, in the western white-pine region be burned in order to reduce the fire hazard. Furthermore, heavy slash may so

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FIG. 1.—A forest of western white pine, cedar, and hemlock in northern Idaho. After this timber is cut the slash must be disposed of to insure natural reproduction and a reasonable degree of protection from fire.

encumber the ground as to prevent satisfactory restocking. This plan is, therefore, eliminated from further discussion in this circular.

Slash disposal in this region is, unfortunately, an expensive operation. The cost to the Government of this measure on national forest timber sales at present represents about 30 per cent of the stumpage value of the timber sold. In 1920 the timber sales on four northern Idaho national forests amounted to $175,000. About $56,000 was needed for the disposal of the slash on these sales. The annual expenditure for this purpose in the same region varies between $50,000 and $60,000.

An annual expenditure of such a sum should reduce fire losses, lower the costs of fire suppression, and insure suitable restocking of cut-over areas. An examination was therefore made of the methods of slash disposal and of the results to ascertain the effectiveness of past and present practice; to discover, if possible, improved methods applicable to national forest lands, and to indicate practices which might be advocated for private forest lands.

The data which are summarized in this report were obtained from three months' work in the field during the fall of 1920. Examinations were made of office records for data on old timber sales. Studies

FIG. 2.—Unmerchantable and decayed material left after logging a virgin stand of western white pine. On this area all hemlock and white fir were cut down after logging and the area was burned broadcast. This tract was later burned over the second time and this prevented satisfactory restocking. After 10 years of waiting for reproduction the area was planted.

were conducted in the field on old national forest sale areas to discover the results of past practice, and current sales were examined closely to gather information on the present methods and the administrative problems connected with the work of slash disposal.[1]

[1] Field examinations were made on 19 sale areas for the purpose of obtaining accurate information on the amount and character of the material left, on the extent and kind of natural restocking, and on the results of the burning of slash. These data were obtained by running strip surveys with compass and chain across the logged-off tracts. On each square chain counts were made of standing trees, both those that were living and those that were killed by slash burning. Counts were also made of material on the ground, including old logs, new cull material, and windfalls. On each chain length of a strip one-fourth or one-eighth chain wide the reproduction was tallied by species and by burned and unburned surfaces. The percentages of the two surfaces were obtained by ocular estimates on each chain length. Data on the amount of slash and the number of slash piles per acre and on the percentage of the forest floor covered by the piles were obtained on plots containing 2½ acres and on strips two chains wide. The piles were counted and their dimensions measured to calculate the quantity of slash and the percentage of the forest floor covered by them. Notes were also taken on the type of vegetation that follows slash burning, on the influence of slash burning on the restocking of forest trees, and on the protection of the forest areas from fire. Interviews were held with 25 men, many of whom were fire wardens and lumbermen and not officially connected with the United States Forest Service. The problem was discussed from every angle. Information was sought regarding the methods of logging, the methods used in disposing of slash, the season of burning, the influence of weather, the attitude of operators toward the measure of slash disposal, and the type of organization and kind of men best suited for this work.

STANDARDS OF SLASH DISPOSAL.

The varied conditions which exist in northern Idaho prevent, for the present at least, the establishment of fixed standards for slash disposal. Nevertheless, efficient slash disposal must accomplish certain things. It must attain the silvicultural end of assuring natural restocking of the cut-over areas and the protection end of reducing the fire hazard to the safety point. Moreover, these objects must be accomplished at justifiable costs.

To accomplish the silvicultural object of slash disposal, it is essential to save the seed trees from fire, to prevent the burning and destruction of reserved trees and advanced growth, and to preserve a large percentage of the duff layer from destruction. To be effective, the measure must assure the maintenance of forest conditions and favor sufficient natural restocking for a new stand. It is significant that in nearly every place where the fire hazard is reduced to the safety point the silvicultural needs of the tract are also satisfied.

The second object of slash disposal is to reduce the fire hazard to the safety point. It should be made clear at the outset that there is no method for the disposal of slash that will reduce the fire hazard to zero in this region. It is also an outstanding fact from past experience that the fire hazard can not entirely be eliminated anywhere by slash disposal, and, furthermore, that fire protection can not be dispensed with on sale areas where the slash has been piled and burned. In fact, any cutting in western white pine stands opens the tract to the action of sun and wind and increases the hazard above that of the uncut green timber. Consequently a more intensive patrol system is required to provide the same degree of safety on a logged-off tract than on a tract covered with green timber. For practical purposes it may be said that whenever slash has been removed to an extent sufficient to make it possible to fight a fire on the cut-over tract in the fire season with a reasonable chance of success, the safety point has been reached.

For the present purpose the hazard of the green timber is arbitrarily placed at 1 in a scale of 1 to 10. The maximum will then be represented by 10, which expresses the hazard of a heavy cover of logging slash. It is not generally possible to reduce the hazard below two on logged-off tracts even by the most approved methods of slash disposal.

COSTS OF SLASH DISPOSALS.

What constitutes a justifiable cost of slash disposal is not so readily determined. The expenditure which is justified can not be arbitrarily fixed. Too much or too little may easily be spent. Estimates of what is a proper cost of slash disposal may be made in several ways. Of these, two are presented below. First, the expenditure for slash disposal per acre is considered as limited by the cost of broadcast burning and planting per acre. As a gauge this method has certain disadvantages which will be considered later. Secondly, the maximum justifiable expenditure for slash disposal will not exceed the difference between the total cost (cost of suppression plus the amount of damage) from fire on a tract on which the slash has been burned and the sum of the same costs on a tract of equal fire hazard on which the slash has not been burned. For this method

it was impossible to obtain data covering as wide a region as could be desired; but the figures established give, it is believed, an indication of the justifiable expenditure for slash disposal as a means of protection alone.

In considering the combination of broadcast burning and planting as limiting the maximum expenditure for slash disposal, it must be stated that broadcast burning fails as a means of protecting the forests from fire. The forests of northern Idaho contain many unmerchantable trees which, because of undersize, lack of demand for the species, or decay, are left in the woods. These trees are usually killed by the broadcast fire and are later wind thrown. The great piles make an impassable tangle of inflammable material. To render such an area safe from the protective viewpoint the trees left standing must be felled before the burning. The costs of the combined measure will therefore include (1) the cost of felling the unmerchantable trees, (2) the cost of burning, and (3) the cost of planting. No consideration is here made of the loss represented by the killing of undersized trees. These three items of cost range as follows:

	Per acre.
Felling unmerchantable trees	$4.00 to $10.00
Burning without fire line	.50 to 2.50
Planting	8.00 to 12.00
Range	12.50 to 24.50

If the above figures are applied to an average merchantable stand of 25,000 board feet per acre, the maximum justifiable cost per thousand board feet for slash disposal varies from 50 to 98 cents.

By the second method the difference between the cost of fire (suppression plus damage) on logged-off areas on which slash had been burned and the cost where the slash had not been disposed of was calculated for the Coeur d'Alene and Kaniksu National Forests. An analysis was made of 334 fire reports of the Coeur d'Alene for the period from 1916 to 1920. The reports cover all the fires fought by the personnel of the forest on both Federal lands and on State and private lands under the cooperative agreements. The results of this analysis are set forth in Table 1.

TABLE 1.—*Analysis of 334 fire reports, Coeur d'Alene National Forest, covering a period of 5 years, 1916 to 1920, inclusive.*

Number of fires.	Average per fire.		
	Area.	Suppression costs.	Damage and losses.
	Acres.		
(1) Within cut-over areas, 93 fires—			
Slash disposed of, 45 fires	5.27	$63.09	$1.34
Slash not disposed of, 48 fires	116.64	1,220.50	677.16
(2) Outside cut-over areas, 241 fires	12.05	98.56	51.60

The total number of fires on the cut-over areas was 93. If the average area, the average suppression cost, and the average losses for the fires, first on the areas on which the slash had been disposed of, and then on the areas on which the slash had not been disposed

of, are multiplied through by 93, the results given in Table 2 are obtained.

TABLE 2.—*Costs and damages of fires on cut-over areas where slash was and was not disposed of—Coeur d'Alene National Forest over period 1916 to 1920, inclusive.*

[Fires on cut-over areas, 93.]

Total of averages×93.	Slash disposed of.	Slash not disposed of.
Total area burned over, acres	490	10,848
Total suppression costs	$5,867	$113,506
Total damage losses	125	62,976
Total cost and loss	5,992	176,482

From Table 2 it is learned that if no slash had been disposed of on any part of the area over the 5-year period, the total cost and loss would have been $176,482. It is assumed that the 93 fires would have occurred as they did; that the averages for the fires on the areas on which the slash was not disposed of would have held for all the 93 fires as they did for the 48 fires. If this $176,482 is distributed over the cut of 150,000 board feet for the 5-year period, the cost and loss chargeable against each thousand board feet of timber cut is $1.17. This amount would represent the maximum permissible charge per thousand board feet for slash disposal if the measure eliminated all fires.

If, on the other hand, all the slash had been disposed of, the cost and loss would have been $5,992. When this amount is distributed over the cut it becomes 4 cents per thousand board feet. The effectiveness in the reduction of fire hazard of slash disposal carried out on the Coeur d'Alene National Forest during the period of this comparison is that which is generally attained by the measure. The figure of 4 cents per thousand board feet represents, therefore, an inevitable cost—the approximate cost of suppression and loss from fires which will occur on cut-over lands on which slash is disposed of.

The difference, then, between $1.17 and 4 cents is $1.13, and this represents the maximum justifiable expenditure per thousand board feet for slash disposal as a means of protection alone, under conditions which prevailed for a 5-year period. This figure may, therefore, be taken as a reliable indicator.

In a sense, a cost of $1.13 per thousand board feet is an understatement of the facts. If the figures for the Joki fire on the Coeur d'Alene Forest in 1919 were included in the averages, a much larger justifiable expenditure would be set up. Because the Joki fire occurred under conditions so peculiar and so favorable for its spread, and as it swept over both cut and uncut areas, for the sake of conservatism it is omitted. If, however, as a matter of interest, the figures for this fire also are included in the calculation the difference becomes $3.65 per thousand board feet. For practical purposes, however, the figure $1.13 is accepted as the maximum.

A similar calculation was made for the Kaniksu National Forest over a 4-year period from 1916 to 1919, inclusive. The amount per thousand board feet shown in favor of slash disposal is $1.29. On the basis of these calculations, costs up to at least $1 per thousand

board feet for slash disposal are justifiable for the protection of the forest from fire.

Justification of a cost on other grounds than that of protection is more difficult. Immature trees, advanced growth, reserved trees, and forest conditions all have a value which is destroyed by fires. When slash disposal reduces these losses a further justification of the operation exists, but it is not possible to state exact amounts.

Slash disposal is therefore amply justified for the reduction of fire hazard, and is further justified to an unknown amount for silvicultural reasons which are discussed later.

METHODS AND RESULTS OF SLASH DISPOSAL.

Slash left after logging in the western white pine stands has been disposed of (1) by burning broadcast, (2) by piling and burning in two operations, and (3) by forced burning or live burning, "Forced burning" is a phrase used to define the piling and burning of slash in one operation.

The broadcast burning of slash was formerly used on national forest areas which had been classified as agricultural land. It is now the common practice on private cuttings in this region, but piling and burning is the usual practice on the national forests. The method of forced burning has not hitherto been in general use on the national forests, but the results on recent operations indicate that there is a distinct advantage in the employment of this method and suggest a more extended use of it in the future. To burn the slash currently with logging is in most instances not practicable, Burning while logging or swamping is in progress interferes with skidding, and slash burning is altogether out of the question during the extremely dry summers in the Idaho woods.

BROADCAST BURNING.

Broadcast burning of slash has had a very restricted use on national forest land, and has in all cases been confined to lands to be listed for homestead entry. The practice has failed to produce desired results in protection from fire and in silviculture. It has not only failed to lessen but has often actually increased the fire hazard, and has at the same time destroyed an inestimable amount of young growth and immature timber. Its failure is shown on those areas on national forests which has been classified as agricultural land, and on which the method of slash disposal formerly prescribed was broadcast burning. These areas, along with private forests lands that had been burned broadcast furnished the data for a judgment of the measure, and, although its use on national forest lands has been discontinued, a study of the results of this method has led to conclusions which apply to the extensive private lands adjacent to the national forests.

Broadcast burning increases rather than decreases the fire hazard by killing the trees left in the logging operation. The white-pine stands of northern Idaho contain large quantities of western hemlock and lowland white fir and undersized trees which have no present market value. These are left standing in the logging operations. A broadcast burning of the slash kills all these trees, which begin to be wind thrown three to five years after the burn, and continue to pile up on the tract for several years. (See fig. 3.) They form a

tangle through which travel is slow or impassible. The fire hazard progressively increases up to at least 15 years. To fight a fire on such areas is in almost every instance humanly impossible. The present condition of many so-called agricultural tracts furnishes examples of this fact and provides a testimonial of the futility of broadcast burning as an effective means of reducing the fire hazard after logging.

To render the measure at all acceptable from the protective viewpoint it is necessary to fell the standing trees left after the logging. This is an essential precaution. In those stands, however, in which a

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FIG. 3.—An area which contained more than the average number of immature but defective hemlock. It shows the tangle of fallen trees and the increased fire hazard following a broadcast burn.

very large quantity of standing material is left, the condition of the tract, even after the burning, is not particularly safe. The first burn, especially if it is in the spring, usually consumes only the smaller material and leaves the charred trunks of the felled trees lying high across stumps and cull logs. This condition, however, is much safer than that of an area covered with wind-thrown killed trees. (See fig. 2.)

Table 3 sets forth separately for old and middle-aged stands the averages per acre of material left standing and its condition after broadcast burning.

TABLE 3.—*Material left per acre after broadcast burning of slash.*

[Basis: 7 sale areas.]

	Old stands, 4 sale areas.		Middle-aged stands, 3 sale areas.	
	No. per acre.	Volume per acre.	No. per acre.	Volume per acre.
		M. b. f.		*M. b. f.*
Trees cut	34–85	30–45	.....	25–50
		Cubic feet.		*Cubic feet.*
Surviving trees[1]	5	133	12	144
Trees killed in slash burning[1]	225	1,147	68	515
Snags	10	383	11.5	180
Material on ground in the form of trunks	152	2,570	64	533

[1] Trees measuring 3 inches in diameter breast-high and over.

The old stands show many more snags and much more material on the ground than do the younger stands, and old forests have a larger number of smaller trees which are in danger of destruction by burning than have the younger forests. For these reasons broadcast burning leaves a greater fire hazard in old virgin timber than in middle-aged stands.

Whether broadcast burning takes place in the spring or in the fall of the year makes little difference in the subsequent fire hazard. The burning at either season produces conditions of high inflammability and raises the fire hazard well above the safety point. Frequently more material to feed the fire is provided by the dead remnants of trees and saplings killed and fallen down afterwards than by the slash itself. It is a matter of only a few years after the slash burning before this situation develops.

Silviculturally, however, spring burning shows a distinct advantage over fall burning in that it is followed by a greater amount of reproduction and by the restocking of more desirable species than follow fall burning. This will not be a matter of surprise when it is considered that the restocking of western white pine is dependent chiefly on the seed in the duff layer. In the spring the mineral soil and duff layer are wet from the melting snows. The first warm period dries out the top covering of slash and the upper part of the duff. In the spring the fire runs over the upper surfaces, burning the leafy part of the slash and only the dried portion of the duff stratum, and thus some of the white pine seeds are saved. Fall burning, on the other hand, occurs under quite different conditions. The duff layer and the mineral soil both become dry in the summer. Although the early fall rains dampen the upper layers of the slash and duff, the fall burn consumes the slash and the duff down to the mineral soil, and destroys all stored seeds. The results that follow burning at the two seasons, as shown in Table 4, clearly indicate a difference in the moisture condition of the duff layer and prove that greater damage is done to seed by fall than by spring burning.

TABLE 4.—*Natural reproduction following broadcast burning.*

[Number of seedlings per acre. Basis: 12-sale areas.]

Natural reproduction by species.	Number of seedlings per acre.			
	Spring burning.		Fall burning.	
	Unburned.[1]	Burned.[2]	Unburned.[1]	Burned.[2]
Percentage of area burned over	18	82	7	93
Western white pine	818	603	751	37
Western red cedar	301	90	.....	4
Western hemlock	1,065	2,099	7	4
Lowland white fir	806	425	.....	.....
Western larch	162	297	54	828
Douglas fir	215	256	48	.....
Lodgepole pine	.....	.....	104	132
Miscellaneous	25	21	27	6
Total	3,392	3,791	991	1,011
Average per acre	3,719		1,010	

[1] Represents portions of area which the broadcast burn missed.
[2] Represents portions of the area over which the fire burned.

Table 4 shows that not all of the ground cover is consumed either by the spring or the fall burning. To be sure, the percentage of advance growth seedlings destroyed by the latter is much greater, and more new seedlings of white pine appeared on the surface burned in the spring than in the fall. This is accounted for by the moister condition of the duff in the spring than in the fall. Furthermore, it is worth noting that a greater number of hemlock, white fir, and cedar seedlings appeared after the spring burns. This is accounted for not only by the less severe spring fires and the survival of more trees of these species, but also by the protection which these species furnish. On the fall-burned surfaces, on the other hand, western larch and lodgepole pine seedlings predominate. These are of less commercial value than cedar and white pine. Obviously, therefore, if broadcast burning is practiced at all, it should take place in the spring in order that more desirable silvicultural conditions may be obtained.

A disadvantage of broadcast burning which has too often been overlooked is the ensuing unfavorable condition of the land viewed from a forester's standpoint. In place of the thin evergreen vegetative cover of the forest floor a dense annual vegetation of firewood, thistles, grasses, and sedges invades the burned tract. (See figs. 4, 5, and 6.) This cover competes directly with seedlings for the available soil moisture, and on the more critical sites none but the hardiest species, as, for instance, lodgepole pine, will survive. In the late summer this vegetation dies, dries out, and becomes a serious fire menace. When fanned by a wind, the dry material carries a fire as does dry grass on the prairie, thus adding to the difficulty of fire suppression. With the increased air temperatures and wind movements that take place on cut-over tracts, the conditions on areas that have been burned broadcast are rendered critical as to seedling survival and the rapid spread of fire.

The abundant reproduction which often follows forest fires in virgin timber is frequently cited as an argument for the broadcast burning of slash on cut-over areas. But seeding in on burns in green timber

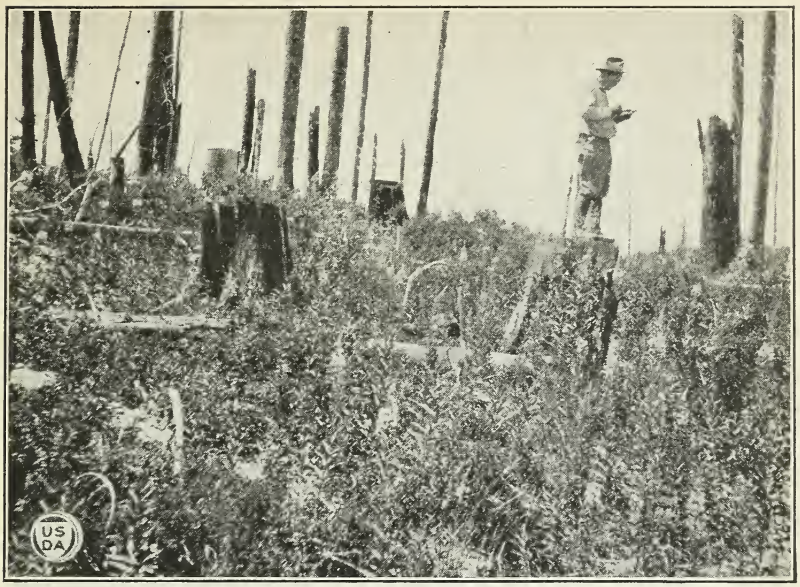

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FIG. 4.—First stage of vegetation following two fires which ran broadcast over the area. Note the dense cover of fireweed and thistle. This dries up in late summer and becomes highly inflammable.

can not be compared with that which follows fires on logged areas. A portion at least of the seed within the tree cones is mature at the

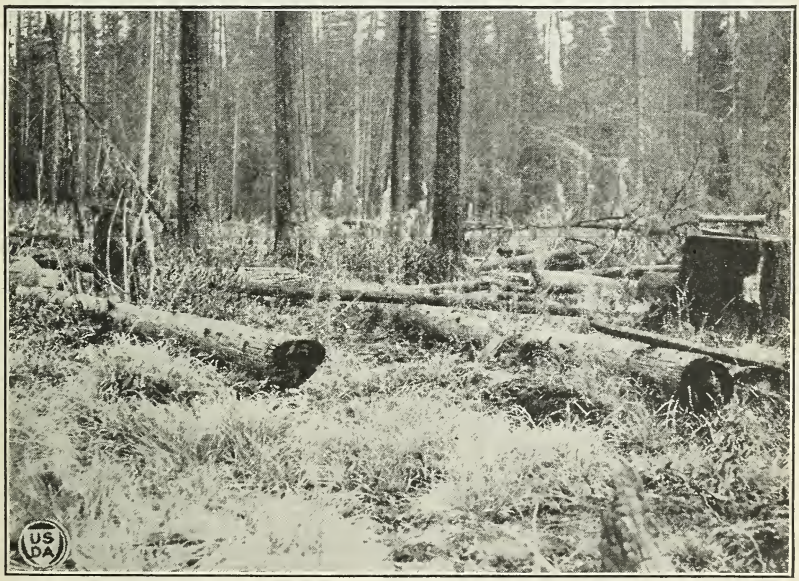

FIG. 5.—Second stage of vegetation on an area burned broadcast over which three or more fires have swept. The forest cover is eliminated. The heavy sod cover prevents natural restocking of forest trees, and the grass burns readily in July and August.

time forest fires most commonly occur in green timber. The green cones preserve the seed, and this is afterwards shed upon the ashes. There it finds conditions favorable for germination and survival. Furthermore, certain trees escape destruction and later furnish an additional supply of seed. On logged land, on the other hand, seed-bearing trees are removed. A heavy covering of inflammable material creates a hotter fire at the surface than does the surface fire under green timber. This fire burns down to the mineral soil over a larger percentage of the area than does the forest fire in the uncut forest. The chance for the stored seed is also very much less. There is no

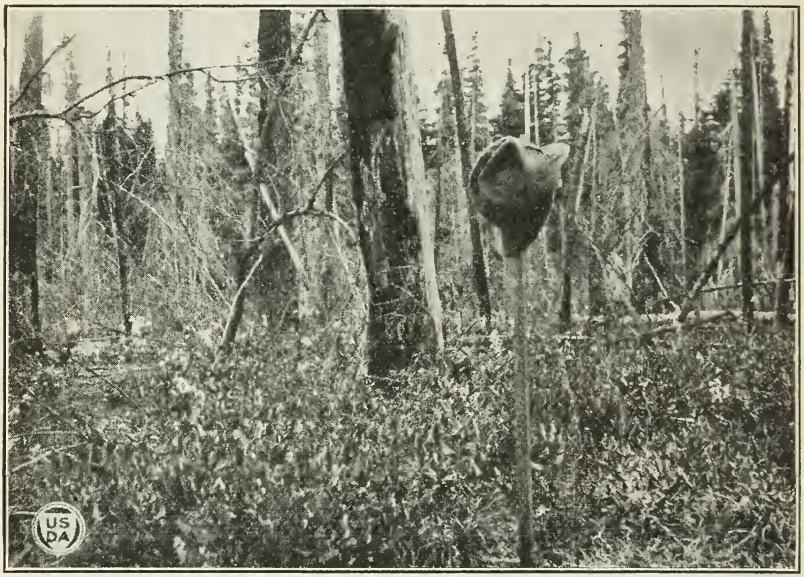

FIG. 6.—A third type of vegetation following broadcast burning after logging. On nearly all such tracts there are alternating patches of the second sedge stage and the third brush (*Ceanothus*) stage shown here.

assurance that good restocking will follow a broadcast burn of logging slash as it does a forest fire in the green forest.

The requirements of silvicultural practice in the forest stands are met by three separate operations, each of which involves considerable expense. These operations are felling unmerchantable trees before the burn, building fire lines, and burning the slash itself.

The following are average and range costs for the three operations:

Felling per thousand board feet	$0.40
Building fire line per lineal mile	125.00–200.00
Burning per acre	.25– 2.00

If to an average stand for the region, containing 25,000 board feet of merchantable trees and 10,000 board feet of unmerchantable trees per acre, a typical charge is applied, the costs are as follows:

	Per acre.
Fire line, 1 mile for 40 acres, at $160 per mile	$4.00
Felling 10,000 board feet of unmerchantable trees, at 40 cents per thousand	4.00
Burning slash	1.25
Total, without planting	9.25
Cost of planting	10.00
Total, including planting	19.25

The cost of over $9 per acre for broadcast burning appears high and is more than it costs the private operator to do it. This cost involves the precautions necessary to make the method effective for protection and to prevent the escape of fires to adjoining areas. Uncontrolled burning, on the other hand, may be done at a lower cost and may be postponed to a time when conditions are such as to favor the rapid spread of the fire. A conflagration usually results when the slash is ignited. Often it is necessary to fight the fire beyond the limits of the cutting area. This is particularly true when an older cut-over area adjoins the tract on which the slash is being burned. If the expense of fire fighting is charged against slash disposal, as it should be, the cost may run up to a considerable figure. The present methods of accounting, however, place fire-fighting charges under a different heading, and they are therefore lost sight of. It is not possible to escape a considerable charge for slash disposal, whatever methods are employed, and it often happens that an attempt to secure very low costs results in high ones. The use of definitely controlled methods of slash disposal whose results can be foreseen should be the more satisfactory and the less expensive for continued practice.

PILING AND BURNING OF SLASH.

The disposal of slash by piling and burning in two separate operations is the standard practice on national forest lands. The piling consists of collecting into compact heaps all logging débris, including limbs up to 4 inches in diameter. The piles are later burned at a favorable season of the year when the burning may be safely done.

Piling the slash has proved to be an important operation. Its technique requires much attention. The primary object of the piling is to make possible the complete burning down of the piles at a time of the year when the woods are damp and a fire will not run widely over the cut-over tract. Simple as it may appear, it has proved very difficult to secure satisfactory piling of slash. Piles must be large; they must be compact in order to shed snow and rain and burn down clean. In the white-pine region the tepee-shaped pile has proved unsatisfactory. Experience has shown that the most compact pile is made by placing the long branches all in one direction. The material so arranged settles together during the burning, and thus the cooling of isolated branch stems below the combustion temperature is prevented.

Locating the pile is another important part of the slash-disposal operation. Inexperienced men need close supervision in order that the needless expense of repiling slash and the needless damage to trees

when the pile is burned may be avoided. Some foremen of slash-piling crews have found it good practice to designate by driven stakes the correct position of the pile with respect to reserved trees, snags, down logs, and young growth. The fire of the piled slash should neither kill nor injure reserved trees and advanced growth nor ignite snags and down logs. When the fire once gets into snags and cull logs, there is danger that it will hold over until later in the dry season after the crew has finished work. This often happens when the slash is burned in the spring. Piles should be compact as so to burn clean to the ground and isolated so that the fires will burn themselves out.

Care in the location of piles on slopes is even more important than on flats. The fire draws up along the slope and endangers reserved trees on the uphill side that would be safe on the flats. It is especially important that snags and cull logs on the slopes be not ignited,

FIG. 7.—Great quantities of slash are left on the ground after logging in western white pine forests of Idaho. Here 50,000 board feet per acre were cut. The slash is piled and is ready for burning.

otherwise they may spread fire down the slope. The snags may be burned off and slide down a steep grade, scattering the embers. Cull logs are often dislodged by fire, and portions of them roll down the slope. In this way fire may be set generally over a slope and a broadcast burn result. Under these circumstances the crew may lose control of the fire and the purpose of the entire operation be defeated.

It is essential that slash be piled as soon after the logging operation as possible. It has been found that green slash can be handled at a cost of 25 to 30 per cent less than old slash. Not only is green slash easier to handle, but the work is more agreeable to slash pilers. While the slash is yet green, or not more than 6 months old, the waxy coating of the bark remains impervious to water and keeps the branches from becoming water-soaked. Consequently, the branches

are fairly dry and burn readily even in damp weather. Green slash is easier to pick up and handle than than old slash. Furthermore, prompt cleaning up of slash materially reduces the cost of fire protection in general and lessens the nervous strain on the protective force during the dangerous season. All factors, therefore, point to the desirability of prompt disposal of slash.

To burn slash piles properly is at best a difficult operation. It requires sound judgment and knowledge of the pranks of fire and the tricks of wind currents in the woods. The air drafts caused by the fires incline toward the slopes, snags, and green trees. This is because the air near the heated stems or surface begins to rise sooner than elsewhere. The soil covering on the uphill side of burning piles is dried out by the inclining flame, and this favors the spreading of fire up the slope. The difference in the inflammability of the forest

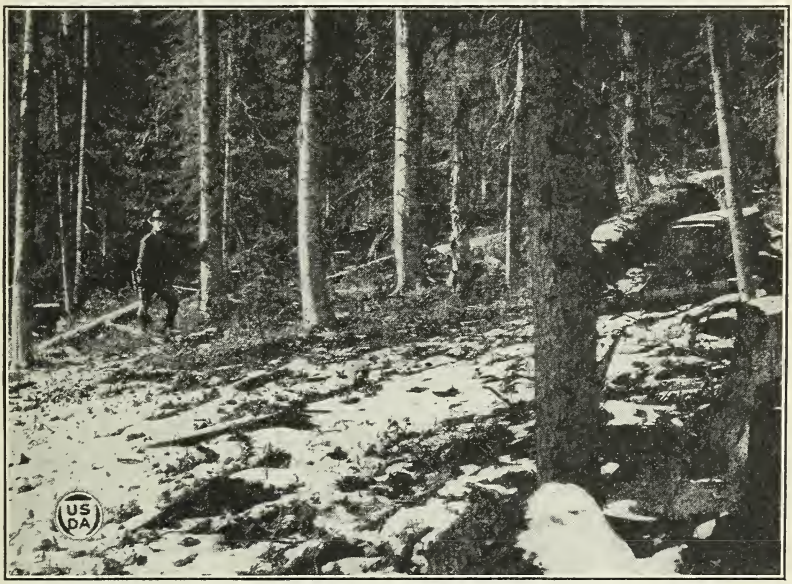

FIG. 8.—An area on which the piling and burning of slash preserved a considerable stand of immature trees. This is left in condition to favor natural reproduction, and the danger of slash and grass fires is eliminated.

floor in early morning and in mid afternoon is not often fully realized. The drying effect of fires, the stimulation of local wind currents on slopes, and the lowering of the humidity render a tract much more inflammable at 3 o'clock in the afternoon than at 8 o'clock in the morning, when the air is calm and dew is on the ground. It is a rule to which there are no exceptions that the burning of slash piles shall begin at the top of the slope. Also, if the lighting of all the piles at one time would cause strong and dangerous local winds and increase the inflammability of the forest floor, alternate piles or single piles here and there should be first lighted and allowed to burn down before the remainder of the piles are set afire. At all times it is necessary that the fire be kept in control. This requires on the part of the crew a knowledge of the action of fire and wind in the woods on the several exposures and degrees of slope. It is a precarious

operation which calls for seasoned judgment and is dangerous if left to untried men. An area where the slash is quite heavy is shown in Figure 7, and a tract on which the slash has been burned is seen in Figure 8.

The operations of piling and burning are directly affected by the quantity of slash which is left by a logging operation. The quantity of slash in different stands affects both the results and the costs of its disposal. A summary of the data collected on eight representative sale areas is given in Table 5.

TABLE 5.—*Quantity of slash in white pine stands.*

[Basis: 8 sale areas.]

Tracts	1	2	3	4	5	6	7
Type of stand	A	A	B	B	B	B	C
Number of trees per acre cut	79	(?)	28.5	39.2	75	50.6	50
Volume cut per acre, thousand board feet	45	34.7	30.5	42	46	29	35
Percentage white pine	80	50	95	63	95	84	40
Number of slash piles per acre	44.6	50	57	55	54	40.4	53.5
Percentage of area covered by slash piles	20	25	13.6	38	27	21	25.5

A, fairly young; B, mature; C, overmature.

The data in Table 5 show that the number of slash piles per acre resulting from the cutting of average white pine stands varies from 40 to 57. These piles have a range in circumference of 50 to 60 feet and in height of 4 to 5 feet, and cover from about 15 to 40 per cent of the surface.

In the main, there is more slash per thousand board feet in young and overmature stands than in mature stands. In the younger stands the quantity of branches has a higher ratio to volume than in middle-aged forests. In the overmature stands the understories of tolerant species, as well as the spreading crowns of old trees near openings in the timber, increase the quantity of slash considerably. In a light cut the slash piles are nearly as numerous as in heavy cuts, but the quantity of slash contained in each pile is less.

The condition of areas on which slash has been piled and burned is shown in Tables 6 and 7. In Table 6 are listed the average number per acre of trees left living and those killed by burning, etc. The results obtained by broadcast burning set forth in Table 3 may be compared with those set forth in Table 6.

TABLE 6.—*Material left per acre after piling and burning slash.*

[Basis: 9 sale areas.]

Item and condition.	Per acre.	
	Number.	Volume.
	Trees.	*Cu. ft.*
Trees cut	40	.....
Living trees [1]	97	6,512
Trees killed in slash burning [1]	12	1,360
Trees lost by windfall [1]	12	1,954
Snags	14.5	.....
Material on ground in the form of trunks	.....	5,445

[1] Trees measuring 3 inches in diameter breast-high and over.

TABLE 7.—*Natural reproduction on areas where slash was piled and burned.*

[Number of seedlings per acre. Basis: 4 sale areas.]

Seedlings per acre by species.	Surfaces.		Seedlings per acre by species.	Surfaces.	
	Burned, 30 per cent.[1]	Unburned, 70 per cent.[2]		Burned, 30 per cent.[1]	Unburned 70 per cent.[2]
Western white pine	2	1,372	Douglas fir	0	11
Western red cedar	0	165	Lodgepole pine	0	183
Western hemlock	31	3,663	Miscellaneous	0	0
Lowland fir	0	235			
Western larch	8	202	Total	41	5,831
Per acre stocking					4,094

[1] Burned surface is that represented by the spots where the slash piles were burned.
[2] Unburned surface is that surrounding the burned spots.

By this method of piling and burning slash an average of 4,094 seedlings per acre is assured, as compared with 3,719 after spring broadcast burning and 1,010 after fall or summer broadcast burning. As the method of piling and burning slash is followed by a larger percentage of western white pine seedlings than are the other methods, there will be a heavier yield of the most valuable species in the future stands.

The cost of piling and burning slash varies with the type of labor and with working conditions. A good man on a contract basis will pile 15 to 20 average-sized piles per day; the day laborer will average about 10. The topography and the amount of the down material influence the amount of the work accomplished per day. Work goes more slowly on steep slopes than on flats. A heavy understory and much débris retard progress and increase the unit costs.

In an average stand of 25,000 board feet per acre of merchantable species, and 10,000 board feet of unmerchantable species, the costs of piling and burning the slash and of necessary silvicultural measures will be as follows. On the basis of the average figures for the region there are two piles of slash per thousand board feet, or 50 piles per acre. An average workman will pile 10 of these per day. At a wage of $3.50 per day the cost per acre is $17.50 for piling, or 70 cents per thousand board feet. Burning may be done for 5 cents per thousand. This makes a total charge of 75 cents per thousand board feet, or $18.75 per acre against the merchantable timber for piling and burning. In some parts of the region a fair average cost per thousand board feet for the piling and burning of slash has been found to approximate one-sixth of a swamper's gross daily wage. If, however, such silvicultural measures as the elimination of unmerchantable hemlock and white fir are necessary in this stand in order to favor the reproduction of white pine, an additional charge is required. It would then be necessary to fell about half, or 5,000 board feet, of the unmerchantable hemlock and pile and burn the resulting slash. The additional costs would then be as follows:

	Per acre.
Felling 5,000 board feet, at 40 cents	$2.00
Limbing and piling slash for 5,000 board feet	5.00
Burning slash for 5,000 board feet	.25
	7.25

This amount added to $18.75 gives a total cost of $26 per acre. The cost will vary as the amounts and ratio of merchantable and unmerchantable timber vary.

The method of forced burning has not been used extensively in the white pine stands, but it shows promise of serving well the purposes of the slash disposal. The method combines the piling with the burning. A fire is started, and the slash within a convenient radius is thrown on. Other fires are then started, and the slash is then thrown on until the disposal is complete. The use of this method is limited to the season in which burning is safe. It may, however, be used in winter or at periods when slash piles would be too wet to burn. This method has the particular advantage of a more extended time during which the slash may be burned. The favorable periods in spring and fall are usually too brief for convenience in burning slash piles. By the method of forced burning, less of the forest floor is burned than by that of piling and burning, and this is, of course, an advantage silviculturally. The cost of the forced burning method has not exceeded that of piling and burning and is expected to be even less.

A comparison of the two methods of slash disposal, on the basis of the percentage of area burned over and of the resulting reproduction is made in Table 8.

TABLE 8.—*Summarized results of slash disposal, average per acre.*

[Basis: 19 sale areas.]

Item.	Broadcast burning.		Piling and burning.
	Fall.	Spring.	
Percentage of area burned	93	82	30
Killed trees [1]	174	56	12
Material on ground in board feet	9,500	9,150	5,445
Natural reproduction, seedlings	1,010	3,719	4,094

[1] All trees 3 inches in diameter breast-high and over.

The numerical comparisons of the restocking following the three methods of slash disposal are somewhat misleading. From the figures alone there is not much choice between the spring broadcast burn and the pile and burn methods; but when the restocking by individual species is considered, the advantage of the latter method is evident. For example, on the area on which the slash was piled and burned, the average number of white-pine seedlings is approximately 1,000; on the areas on which the slash was burned broadcast in the spring the average number is approximately 600; and on the areas on which it was burned broadcast in the fall the average number is less than 100. The ratio of the relative advantages of the methods in terms of the most valuable species is 10 : 6 : 1. A further examination of Table 4 shows that the less desirable species are the more numerous on the tracts on which the slash was burned broadcast and on those on which it was burned in the fall. Western larch constituted 70 per cent of the restocking, exceeding all other species. To assure the fullest restocking of the most valuable species the method of piling and burning of logging slash is decisively indicated.

A comparison of the cost of broadcast burning with that of piling and burning can best be illustrated by an average stand of 25,000 board feet per acre of merchantable species and 10,000 board feet per acre of unmerchantable species. Under the method of broadcast burning the cost would be $9.25 per acre, and if the area is planted the cost would be $19.25 per acre. On the other hand, if the slash is piled and burned, the cost would be $18.75 per acre. If one-half of the unmerchantable species is disposed of in order to favor the white pine reproduction, the cost would be $26. This apparent monetary advantage in the method of broadcast burning in many cases will be decreased or disappear in the first few years following slash burning as a result of the increased costs which are necessary for effective protection on areas which have been burned broadcast. In any event, the difference is not sufficient to overbalance the evil results of broadcast burning which have been pointed out but which can not be measured in terms of dollars and cents.

Efficient slash disposal is dependent, however, upon a capable personnel. It is quite as important to have the right type of men to do the work as it is to employ the right method. Middle-aged or older men who are acquainted with woods work prove most reliable. The somewhat disagreeable nature of slash-disposal work and, to some extent, the isolation or monotony of the work, make the employment unattractive to the younger and more restless type of workmen. A supervision of the work requires "woods judgment" and close checking up of each man's job. It often proves advisable to stake out parallel strips of equal width and to assign a slash piler to each strip. The comparative efficiency of each man then shows up in the relative degree of progress made on the strip. The most efficient crew appears to be one of four to six men in which the foreman piles slash a part of the time. If a large area is to be gone over, the crew may be enlarged to 20 or 25 and a full-time foreman placed over it.

SUMMARY.

The quantity of slash resulting from logging operations in the white pine type in northern Idaho and the unusually dry summer conditions combine to make slash disposal a very important and necessary operation. At the same time it proves to be expensive and absorbs about 30 per cent of the stumpage price of national forest timber. An examination of the costs indicates that an expenditure up to $1 per thousand board feet is amply justified on the basis of the reduction of the fire hazard alone. Two methods have been used to dispose of this slash, namely, broadcast burning, and piling and burning.

Broadcast burning as a means of reducing the fire hazard in the white pine type does not prove even partially effective unless all merchantable trees are felled before the burning. In addition to the loss of this material, there is the cost of felling. If these trees are not felled, they are liable to be killed by the fire, later to be wind thrown, and eventually to become a serious fire hazard.

By the method of broadcast burning practically the entire area is burned over. Broadcast burning in the fall destroys all hope of a satisfactory restocking by the desired species. After broadcast burning in the spring satisfactory restocking is possible only under

the most favorable circumstances. This method of burning permits the invasion of a cover of fireweed, thistles, sedges, and grass, which competes with the seedlings for soil moisture and in its dried condition in the late summer becomes very dangerous. Furthermore, this way of burning reduces the soil moisture, impairs the fertility of the soil, destroys evergreen vegetation, and retards the natural return of the desired forest cover. In short, by broadcast burning the forester gives up his control of the factors of site which make for quick reforestation. Broadcast burning in the white-pine type does not meet the requirements of fire protection or of silviculture, and it has a very restricted application as a measure in forest administration.

The method of piling and burning has proved its utility in reducing the fire hazard. It saves the advanced growth and the immature trees which represent considerable periods of growth. It preserves from burning about 70 per cent of the duff layer and retains the evergreen vegetation of the natural forest. It preserves the factors of site. It conserves the soil moisture and maintains conditions that favor the quickest possible restocking by the valuable timber species.

The advantages of the method of piling and burning slash, both as a protective scheme and as a silvicultural measure, outweigh the difference in cost as compared with the method of broadcast burning in the white-pine type.

The method of forced burning has distinct promise of being applicable to this type of forest. It can, perhaps, be used at a somewhat lower cost than attaches to the two separate operations of piling and burning.

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